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ARCHAEOLOGICAL EVIDENCE ON THE EVOLUTION OF MAIZE IN NORTHWESTERN MEXICO

BY

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DESCRIPTION OF THE SITE

ARCHAEOLOGICAL investigations by one of the authors (Lister) were initiated in caves in the northern Sierra Madre Occidental of Mexico in the hope of contributing to the solution of a problem about which students of the cultures of the southwestern United States and central Mexico have frequently speculated—that of possible cultural connections between central Mexico and the American Southwest. Attempts made in the past to link the cultures of Mexico and the Southwest via the west coast of Mexico or the central plateau of northern Mexico have not succeeded. Therefore, attention was focused on the northern Sierra Madre, for it was known that caves containing archaeological material existed in the canyons of that region. Many of these caves were known to include cliff dwellings thought to be associated with the Casas Grandes, a relatively recent Puebloid culture whose remains are concentrated in the basins and valleys of northwestern Chihuahua. It was hoped that, by digging beneath the cliff dwellings, earlier deposits would be encountered and that some of these earlier levels would rep-

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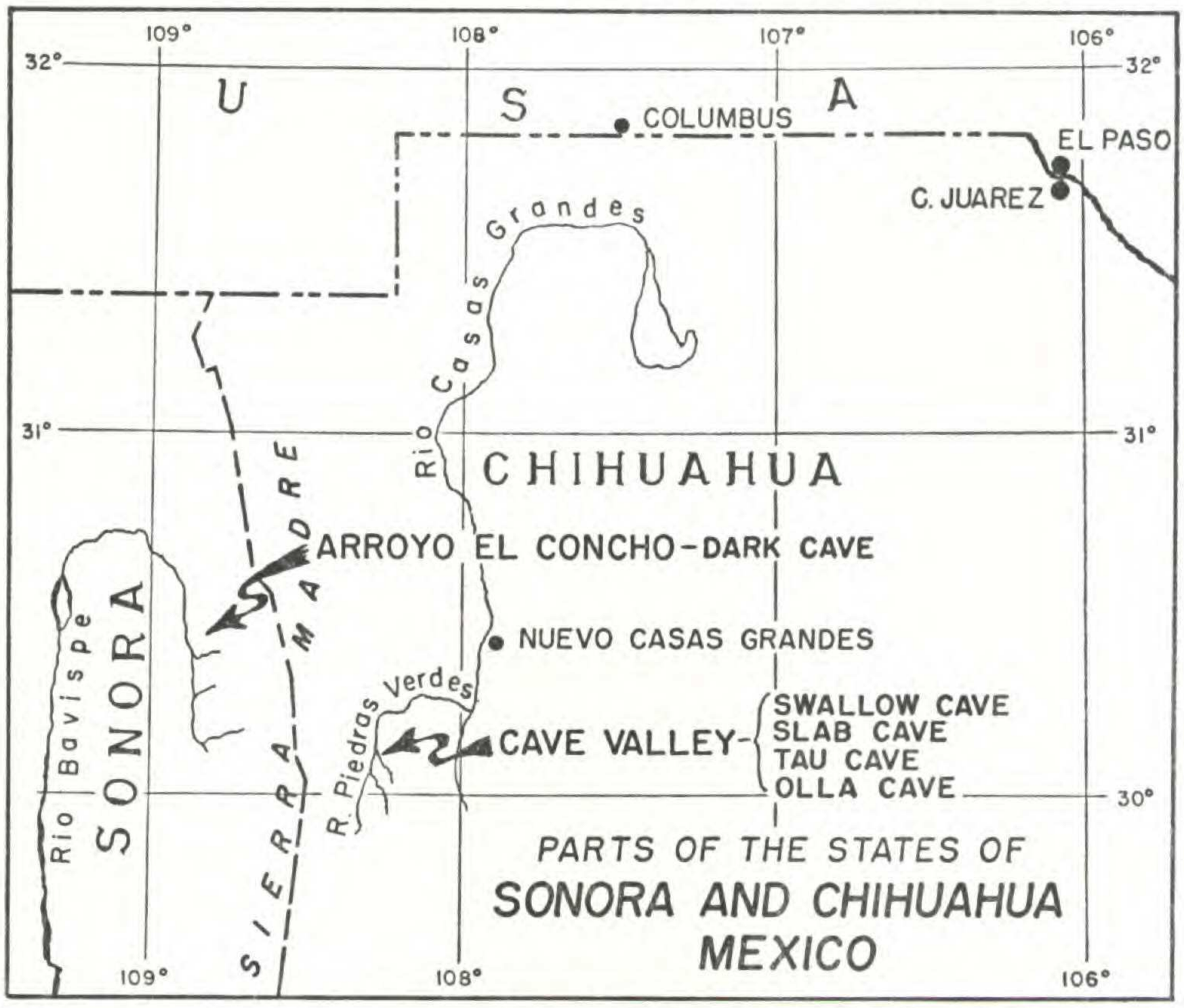
resent a period during which such basic culture elements as agriculture and pottery-making were first spreading from Mexico to the Southwest. It is a satisfaction to be able to report that these hopes have been, in part at least, realized.

In 1952, 1953, and 1955, twelve caves in northwestern Mexico were excavated, five of which contained specimens of prehistoric maize. This paper will not attempt to describe or discuss the archaeological features of these caves in any detail since a report on this subject is nearing completion and will soon be published. The brief archaeological summary and descriptions of cultural stratigraphy which follow are intended only to "set the stage" for the discussion of the maize recovered during the excavations.

The caves investigated are located in the Sierra Madre Occidental of northwestern Chihuahua and northeastern Sonora, Mexico. Most of the Sierra Madre in this area is a plateau surface into which rugged canyons have been cut by stream action. The plateau averages more than 5,700 feet in elevation, with a maximum rise to over 8,200 feet along the crests of the highest ridges. Dissected basins separated by low ridges occupy the areas between canyons. Geologically, the Sierra Madre is composed of a long series of effusives, volcanic material or surface lava, generally lying above intrusive rocks such as porphyry, diorite, and andesite. In places, andesite and rhyolites compose the higher ridges. Conglomerates and sandstones fill a number of old basins. Fertile soils produced by weathering of the volcanic mantle exist in the dales, basins and lower slopes of the ridges. The climate is predominantly temperate; however, one of Mexico's cold poles is in the higher mountains. Nearly three-quarters of the total annual precipitation of 24 inches falls in the summer months of July, August, and

September. Snow occurs in the higher elevations during the winter. The plateau top of the Sierra Madre Occidental is clothed with a fairly pure stand of open pine, which covers the ridges and descends to the bottoms of the upper canyons. The lower canyon slopes and basins have a characteristic juniper-oak-agave association.



Map of parts of the states of Sonora and Chihuahua, Mexico, showing the location of the five caves from which the archaeological maize described in this paper was collected.

Four of the caves from which maize specimens were collected are located in a canyon of the Rio Piedras Verdes in Chihuahua, known to local inhabitants as Cave Valley. This is an area which presented almost ideal living conditions to the Indians who formerly occupied it; today it is settled by Mexican farmers. The interbedded volcanic formations that border the Piedres Verdas have weathered in varying amounts to produce numerous caves and ledges, many of which were occupied by the

aboriginal peoples of the area. Cliff dwellings had been constructed in many of these caves and rock shelters. Refuse deposits of great antiquity exist beneath some of the cliff dwellings and in other caves in which no habitations were built. The agricultural lands of these peoples were located in the wider sections of the canyon bottoms, the tributary arroyos, and on the adjacent slopes. Numerous rock retaining walls, thought to have been associated with agricultural practices, still stand along arroyos and steeply sloping areas of cultivable land.

Swallow Cave. This cave, one of the four located in Cave Valley which contained maize, produced the best archaeological record and the most significant sequence of maize specimens of all the caves examined. Swallow Cave, like the others in Cave Valley, to be mentioned below, is situated about 100 feet above the canyon floor at the top of a steep brush- and tree-covered talus slope (Plate XXXVIII). The cave has a mouth approximately 160 feet in width, and it extends into the cliff to a depth averaging 40 feet. The ceiling is very irregular, but its height is greater than 11 feet throughout most of the central portion. Many large blocks of stone, which had fallen from the ceiling or spalled from the walls, littered the floor. Dirt containing cultural material covered the remainder of the surface. The poorly preserved remains of an adobe-walled structure were located adjacent to a large rock at the northern end of the cave.

Stratigraphic test trenches, from which dirt was removed in 6-inch levels and carefully sifted for archaeological specimens, were dug in Swallow Cave, as well as the other sites to be discussed. In Swallow Cave, trenches 2 and 3, dug adjoining one another in the southern portion of the cave, and an exploratory trench, placed next to the adobe structure mentioned above, produced maize

specimens in association with stratigraphically arranged archaeological material. The deposits in trenches 2 and 3 contained abundant potsherds and other archaeological specimens to a depth of 24 inches (through Level 4); from 24 inches to 42 inches (Levels 5–7) potsherds were scarce, as were other types of archaeological remains; below 42 inches and to the cave floor, reached at a depth of 96 inches (Levels 8–16), the deposit contained no potsherds. However, cultural remains in the form of utilized flakes of stone, charcoal, acorns, and corn cobs were present in these lower levels. The lowest maize came from Level 14.

The exploratory trenching around the adobe wall in Swallow Cave produced a selection of maize from the surface of the cave to a depth of 18 inches. Potsherds were frequent in these deposits.

Slab Cave. This cave is situated adjacent to Swallow Cave and is slightly smaller than the latter. Over half of the floor is covered by large slabs of rock which apparently had fallen from the ceiling. Only shallow deposits, averaging one foot in depth, were present. Potsherds and other archaeological specimens were associated with maize throughout the deposit.

Tau Cave. Located on the same cliff face as Swallow and Slab Caves, Tau Cave has a narrow entrance and then opens out into a circular cavern about 50 feet in diameter. Most of the floor consists of rock. Only around the walls were there accumulations of dirt containing cultural remains, and these were shallow. From these deposits, maize and other archaeological remains, including potsherds, were collected.

Olla Cave. The best-known archaeological site in Cave Valley is Olla Cave. Within the cave is a well-preserved

fifteen-room cliff dwelling and a large grass and mud granary shaped like a water jar or *olla* (Plate XXXVIII). Trenches were dug beneath the floors and walls of the house and in a corridor-like extension of the cave behind the structures. Below the house, 18 inches of dirt containing cultural objects were revealed before the floor was reached. In the rear only the first three levels (18 inches) of a test trench produced refuse and artifacts; however, two human burials were encountered in pits which had been dug to lower depths. Potsherds and maize were present throughout the deposits.

Dark Cave. The fifth cave which yielded the maize discussed in this report, Dark Cave, is located in Sonora approximately 35 airline miles northwest of Cave Valley in a narrow canyon which is known as Arroyo el Concho. This area does not appear to have been as favorable to occupancy by man as was Cave Valley and fewer archaeological sites are located there. A number of caves suitable for occupation exist high on the steep cliffs of the canyon, but the only lands available for cultivation in the area are on precipitous mountain slopes or in narrow arroyos. That these areas were utilized for agricultural purposes is suggested by the presence of numerous rock walls. The canyon was dry at the time of our visit; however, it was obvious that considerable water flows through it at times. A deep stream bed had been cut in the canyon bottom and boulders and rock outcrops have been eroded by running water.

Dark Cave is one of four caves located about 200 feet up the side of the canyon at the top of a talus slope. It has two chambers each approximately 30 feet in diameter situated one behind the other. A cliff dwelling comprising eight rooms in the outer chamber and four rooms in the dark inner chamber had been constructed in the cave.

Trenches were dug in both chambers. Deeper deposits were encountered beneath the structures in the rear chamber. Trench 4 was dug to a depth of 36 inches (six levels) before the rock floor was struck. Cultural remains, including maize, were encountered throughout the deposits.

Cultural Sequences and Affiliations

The analysis of the archaeological remains from the five caves described above, and from seven other caves in the northern Sierra Madre Occidental, provides data which are helpful in characterizing the prehistoric cultural sequence in that region, in setting up an affiliation with a culture in a neighboring area, and to a certain extent, in dating the remains.

It is the opinion of the junior author that the archaeological data furnish the basis for establishing a Chihuahua branch of Mogollon culture. Prior to our research, it was believed by some (Brand, 1953) that the cliff dwellings of the Sierra Madre represented a final stage of Casas Grandes culture. It was postulated that this southern extension of Pueblo culture had developed in the valleys and basins to the east and had then spread to the mountains as a result of pressure of nomadic peoples. This move provided more protective sites at a sacrifice of agricultural land. Other students felt that the cliff dwellings in the mountains, as well as a number of open sites to the east, represented the earliest well-developed phases of Casas Grandes culture (Sayles, 1936). These individuals noted the Pueblo features of Casas Grandes culture, but felt that its earliest manifestation showed relationships to the Mogollon culture which had been recognized to the north in southwestern New Mexico and southeastern Arizona (Sayles, 1936; Gladwin, *in* Sayles, 1936). The above deductions were made mainly as a result of archae-

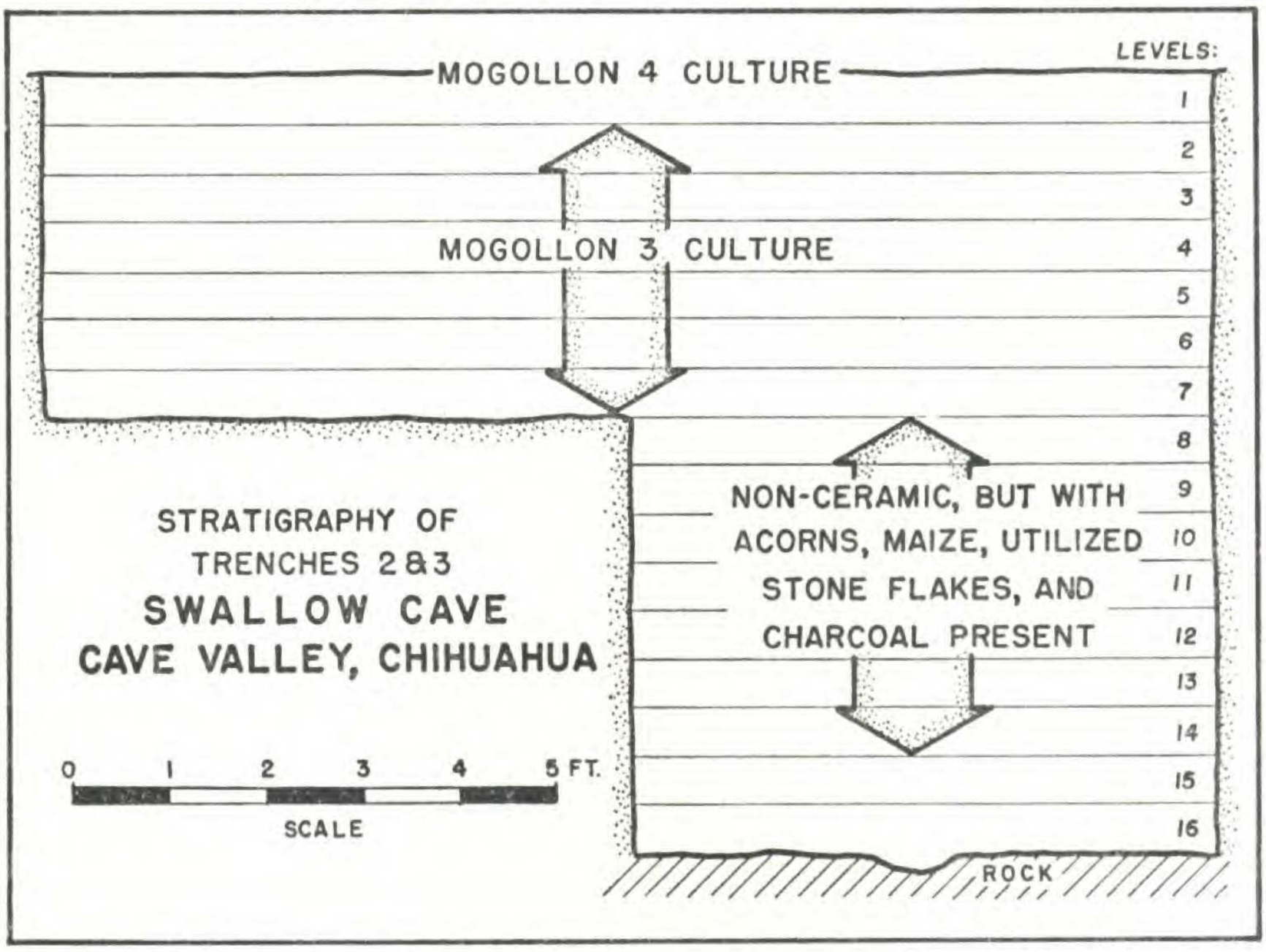
ological reconnaissance and survey in the Sierra Madre sites which involved only limited excavations.

It is now believed that neither of the above concepts is completely correct, but that the one proposed by Sayles and Gladwin comes closest to the situation as it has been revealed by these recent studies. Instead of labelling the culture associated with the cliff dwellings as Casas Grandes, it seems preferable to define it as Mogollon. Also, the cultural remains below the cliff dwellings and buried beneath the surfaces of caves containing no habitations, or simply a few wall remains, are likewise Mogollon. It is assumed that the Casas Grandes culture developed from a Mogollon base and spread eastward from the mountains into northwestern Chihuahua and southwestern New Mexico. One cave, Swallow Cave, produced deeply buried culture-bearing strata lying below Mogollon culture.

As a result of these investigations, the culture history in the northern Sierra Madre Occidental may be briefly summarized as follows:

1. The earliest remains encountered were those found in the lower levels (Levels 8–14) of trenches in Swallow Cave. No pottery occurred in these strata, but maize, acorns, charcoal, and utilized flakes of stone clearly indicate an occupation of the cave. No evidence of permanent habitations was found, so it is assumed that the cave was simply used as a camping place during the period represented by these levels. The presence of maize unassociated with pottery is not unusual, for such occurrences have been reported a short distance to the north in Bat Cave, New Mexico (Mangelsdorf and Smith, 1949) and in other caves in southwestern New Mexico (Martin *et al*, 1952). Cultural remains from this horizon in Swallow Cave pre-date the Mogollon material found above them which is described in the following paragraphs. How-

ever, since our Mogollon remains are not early Mogollon, but probably assignable to the late Mogollon 3 period, they can be dated at approximately 900 A.D. (Wheat, 1955). Just how much earlier than 900 A.D. is the material from the lower levels of Swallow Cave is not known. The presence of maize 30–36 inches below the earliest Mogollon remains suggests that they are considerably



The stratigraphy of two trenches in Swallow Cave, Chihuahua, Mexico, from which the majority of the cobs described in this paper were collected. From Levels 13 and 14, three cobs representing a precursor of the modern Mexican race, Chapalote, were obtained.

older. No dates from radiocarbon have yet been obtained, although it is hoped that such dates may be forthcoming. It is felt that these remains, the earliest we have encountered in the northern Sierra Madre, strengthen the belief that early cultural connections did exist between Mexico and the southwestern United States and that a corridor for movement of such elements was the great Sierra Madre mountain massif with its series of north-south trending canyons.

2. Next in chronological order is the Mogollon culture. It is found in all of the caves we investigated. However, it is difficult to assign our material to definite phases as has been done to the north in New Mexico and Arizona. The rarity of long cultural sequences in most of the caves plus the small series of archaeological specimens makes such assessments enuous. A distinction can be made, however, between the Mogollon culture which is situated stratigraphically lower than the cliff dwellings and that which is associated with such structures.

The sub-surface remains in all caves except Swallow Cave, whose non-ceramic levels are discussed above, contain Mogollon culture remains extending to the rock floors of the caves. These deposits produced pottery, simple stone cutting and scraping implements, artifacts of bone, wood and fiber, and vegetal remains. In some caves there appear to be no habitations associated with these materials, but in others a few poorly preserved mud wall foundations and buried posts suggest houses. These structures, however, are not of the type referred to as cliff dwellings in this paper. They appear to be remains of earlier structures. The pottery is almost exclusively typical of that associated with Mogollon culture. The principal types include: Alma Plain, Alma Scored, Alma Incised, Neck Corrugated, and Incised Corrugated. Although some of these pottery types were common throughout Mogollon history, the presence of certain of them would indicate that the deposits are no earlier than late Mogollon 3, approximately 900 A.D. (Wheat, 1955). Red on brown pottery also is present. Such a pottery tradition agrees with Mogollon, but it is difficult to classify our red on brown sherds as belonging to any previously described type.

3. The most recent remains in the caves, those occurring on the surfaces, were always associated with cliff

dwellings. For the most part, such structures were well preserved and varied in size from a single room to fifteen-room establishments. Archaeological specimens from the surface, or from the first six inches below the surface (Level 1), continued to be of Mogollon culture. Objects of perishable materials such as cordage, matting, textiles, basketry, wooden artifacts, and vegetal remains were fairly prevalent. Stone artifacts and potsherds were more numerous from this horizon than from lower levels. In addition to the Mogollon wares found in the sub-surface deposits, late types such as Plain Corrugated, Smooth Corrugated, and Alma Punched also appeared. Presence of these wares suggests that the material should be assigned to the Mogollon 4 period, approximately 1000 A.D. (Wheat, 1955).

A few potsherds of textured, black on red, and polychrome wares collected from the cave surfaces belong to types assignable to the Casas Grandes culture. It is believed that these represent trade items, since they do not occur frequently enough to suggest local manufacture. The few Casas Grandes potsherds found in the caves belong to wares attributed to the Medanos and Babicora phases, the earliest phases of Casas Grandes culture. Dates of 1000–1100 A.D. have been assigned to these (Sayles, 1936; Gladwin, *in* Sayles, 1936).

Description of the Maize

Once again the botanist is indebted to the archaeologist for furnishing, in the form of prehistoric specimens, highly significant evidence on the evolution of maize. The archaeological maize from these five caves in northwestern Mexico is of extraordinary interest for five reasons: 1) The majority of the specimens are related to a primitive race of maize, Chapalote, which is still grown in Mexico; 2) The earliest archaeological maize appears

to be a precursor of this modern but primitive race; 3) There is evidence of the introduction of an eight-rowed flour corn originally from South America; 4) There is evidence of hybridization with teosinte; 5) These several entities are finally blended into a modern race of maize, Cristalino de Chihuahua, which is grown in Chihuahua today and which has affinities with the maize of the American Southwest.

The botanist is also indebted, in this instance, to the corn breeders of Mexico who, from strictly utilitarian motives, collected, classified, and described the living races of maize of that country. Their monograph on the subject (Wellhausen *et al*, 1952), with its detailed descriptions and excellent illustrations has furnished the clues to the identity of all of the different types of prehistoric maize collected from the five caves described above.

The Principal Types

The prehistoric cobs from these caves comprise five recognizable types, four of which still occur in the states of Sonora or Chihuahua. The remaining type is a now-extinct precursor of one of the four living types. The material from only one of the five caves, Swallow Cave, is sufficiently abundant and varied to show an evolutionary series. The specimens from the other four caves are useful in furnishing corroborative evidence.

Pre-Chapalote. The earliest intact cob, from Swallow Cave, comes from Level 13. This is a carbonized specimen, 3.5 cm. long, having twelve rows with an average of nine kernels per row. In shape, it is quite similar to the earliest cobs from Bat Cave in New Mexico, dated by associated charcoal at 5000 years or more (Libby, 1951), with which it is compared in Plate XXXIX, in-

set. It also resembles the Bat Cave corn in having prominent rachis flaps, cupules widely spaced on the rachis, and long rachillae. It differs from the Bat Cave corn in the surfaces of the cupules, which are quite hairy. Two fragments of cobs, one from the same level and another from an earlier level (14), resemble the intact specimens in their cupules and are therefore presumed to be specimens of the same race.

This early maize from Swallow Cave also shows a resemblance to the modern race, Chapalote, which occurs in the western part of Mexico, and which has been collected from the states of Sinaloa and Sonora (Wellhausen *et al*, 1952). The cob of the early Swallow Cave corn is much shorter than that of modern Chapalote (illustrated in Plate XLV), but it has the same shape, tapering at both ends; the same row number, twelve, and prominent rachis flaps. Of the living races of maize in Mexico today, Chapalote seems to be the only one which could be the modern counterpart of the earliest Swallow Cave corn and we are therefore designating the latter as "Pre-Chapalote."

Early Chapalote. The next recognizable element in the Swallow Cave cobs is clearly related to Chapalote. This type has the characteristic shape of Chapalote, tapering at both ends; it has approximately the same row number, twelve; prominent glumes, perhaps representing a weak allele of tunicate, which Chapalote is known to possess (Mangelsdorf, 1953); and prominent rachis flaps. Cobs of this type, designated as "Early Chapalote" are found in several of the caves. Specimens from Swallow and Slab Caves are illustrated in Plate XL.

Further evidence that Chapalote, or something very much like it, was once grown in this region is provided by the extensive collections of kernels from Dark Cave.

Several thousand kernels of this type are available from Levels 5 and 6; almost all of these are very similar to the kernels of modern Chapalote in their size, shape, and brown pericarp color. Chapalote is the only race in Mexico which has brown pericarp color. The resemblance between the kernels of modern Chapalote and the archaeological specimens is well illustrated in Plate XXXIX, inset.

Tripsacoid Maize. Beginning with Level 2 in Swallow Cave, there is evidence of maize which has been modified by teosinte introgression. Included in this type, designated as "Tripsacoid," are small cobs with strongly indurated glumes and occasional single spikelets or partially aborted second, or pedicellate, spikelets. There is even more evidence of this introgression in certain of the specimens from the surface layer, some of which have strongly indurated crateriform lower glumes, which are set at right angles to the rachis like the teeth of a coarse wood rasp. Glumes of this kind are quite characteristic of certain segregates from maize-teosinte hybrids, and some of these archaeological specimens, like those described by Galinat *et al* (1956), can be almost exactly duplicated by modern specimens obtained from experimental cultures. The combination of indurated glumes and single or partially aborted spikelets leaves little doubt that there has been introgression of teosinte into the maize of Chihuahua in prehistoric times. Teosinte is fairly common in western Mexico and has been collected in the state of Chihuahua. Furthermore, Lumholtz reports that the Indians of western Mexico practiced the custom of interplanting maize and *maizillo* (probably teosinte) for the purpose of improving their maize. Plate XLI shows Tripsacoid cobs from Swallow Cave. The same evidence of teosinte introgression is to be found in the cobs from other localities.

Harinoso de Ocho. First becoming evident in Level 2 of Swallow Cave, there has come into the evolutionary picture an eight-rowed large-seeded corn, similar to Harinoso de Ocho (illustrated in Plate XLVI), which is still occasionally found in western Mexico in the states of Sinaloa and Sonora. Wellhausen *et al* (1952) described this race and postulated that it was introduced into Mexico from South America in pre-Columbian times. It has subsequently been found in Colombia, where it is known as "Cabuya" (Roberts *et al*, 1955). This race also shows some resemblance to the prehistoric flour corn of Cañon del Muerto, described by Anderson and Blanchard (1942), and it probably has affinities with the eight-rowed flour corn of the Northern Plains Indians, especially the Mandan. Specimens of archaeological cobs of this type of corn are illustrated in Plate XLII and a single kernel from Dark Cave is illustrated in Plate XLIV, Fig. A.

Cristalino de Chihuahua. The fifth type of corn in Swallow Cave is (with the exception of two cobs in Level 3, which may be intrusions) found only in Levels 1 and 2. The cob of this maize is larger than that of any of the preceding types, is more or less cylindrical in shape, and represents an excellent blending of the characteristics of the three preceding entities: Chapalote, Tripsacoid maize, and Harinoso de Ocho. The cobs of this maize have their counterparts in a modern race collected in Chihuahua and described by Wellhausen *et al* under the name Cristalino de Chihuahua (Plate XLVII). The archaeological cobs are shorter than typical cobs of the modern race, but in other respects they are quite similar. Furthermore, the kernels from several of the caves resemble the kernels of the modern race, in being thick, flinty, sometimes slightly dented, and predominantly white. This type of corn has affinities with the modern

corn of some of the Southwestern Indians. We have found counterparts of it in both Zuni and Navaho maize.

Some of the cobs of Cristalino de Chihuahua have a very definite "honeycomb" aspect, which results from the deep pockets formed by the upper and lower glumes. This represents a combination of characteristics provided by the three separate elements which have gone into this maize. Chapalote has contributed long glumes; as already mentioned, it is known to have an allele at the tunicate locus. Harinoso de Ocho has contributed thickness to the glumes; and introgression from teosinte has caused the glumes to be slightly indurated. By crossing segregates from maize-teosinte hybrids with a stock carrying the gene for half tunicate, we have produced specimens of modern maize which duplicate these cobs very closely. These deep pockets on the cob are characteristic also of some of the maize of the Indians of the Southwest.

Detailed Descriptions

The specimens from the several caves are described in detail below:

Swallow Cave

Trench 3, Level 14 *(78–84″).* Fragments of a carbonized cob, containing the same type of cupules that are found in the intact cob from Level 13. The cupules are about as broad as long, the upper margin being slightly indented at the center, giving the cupule a broad, heart-shaped appearance. There is an indication that the cupules are widely spaced; their surface is hairy. These fragments probably represent cobs of Pre-Chapalote.

Trench 3, Level 13 *(72–78″).* One intact cob carbonized, slightly flattened, 3.5 cm. long, with twelve rows, nine kernels per row. Shape of cob similar to those of earliest Bat Cave corn. Other similarities: cupules widely

spaced on rachis, prominent rachis flaps. The cupules differ from those of Bat Cave corn in being slightly broader than long and in being more hairy. The rachillae are long.

A fragment of cob from this level apparently belongs to the same race, since it is twelve-rowed and has similar cupules. This fragment is somewhat flattened. Both of these specimens represent Pre-Chapalote.

Trench 3, Level 3 (12–18″). One intact cob, 7.5 cm. long, with ten rows, tapering at both ends. This is probably an early form of modern Chapalote.

Six fragments with twelve, eight, ten, ten, eight, ten rows respectively.

Two fragments representing eight- and ten-rowed cobs with long glumes; both upper and lower glumes are thick and fleshy. These are similar to some of the cobs from the surface layer. They may be intrusions.

Trench 3, Level 2 (6–12″). Three intact cobs, 6, 7, and 7.5 cm. in length, ten-rowed, tapering at both ends, similar to the intact cob in Level 3, and, like it, probably representing an early form of Chapalote.

One intact cob, 5 cm. long, six-rowed, highly Tripsacoid; indurated glumes and rachis; crateriform lower glumes; some single spikelets. The specimen can be matched almost exactly by segregates from maize-teosinte hybrids. An additional fragment, badly eroded through charring, may also be Tripsacoid.

Twenty fragments, predominantly ten-rowed, all of which resemble, in general characteristics, the intact cobs of Early Chapalote.

Five fragments of an eight-rowed maize with a slender cob and glumes, a combination of characteristics which suggests that the cobs bore large kernels. These are related to Harinoso de Ocho.

Six fragments of a type similar to the modern race Cristalino de Chihuahua. Ten- to twelve-rowed; long glumes; both upper and lower glumes thick and slightly indurated.

Trench 3, Level 1 (*0–6″*). One intact cob, 4.5 cm. long, ten-rowed, highly Tripsacoid. Rachis and glumes strongly indurated; a few single spikelets.

Six fragments approaching Chapalote in type; five which approach Harinoso de Ocho, and three which are similar to those of Cristalino de Chihuahua.

One kernel, broad, flinty and brown in color.

Structures 1 and 2 (*0–18″*). The intact cobs comprise two distinct groups. The first includes eight cobs of the type Cristalino de Chihuahua, which results from the blending of the characteristics of earlier elements—Chapalote, Harinoso de Ocho, and teosinte. The cobs are medium to long, 10, 12, 13, 13, 14, 17.5 and 23 cm. respectively. They are predominantly ten- to twelve-rowed with long, thick glumes which are slightly indurated.

The second group, comprising ten intact cobs, are all highly Tripsacoid. Lengths 6.5, 7.5, 8, 8.5, 8.5, 9, 9, 9.5, 9.5, 11 cm.; all have indurated glumes and rachises. In some specimens, the glumes are crateriform and highly indurated. There are no single spikelets; but in several of the specimens, the second, or pedicellate, spikelet is greatly reduced in size—a condition which represents a transition between double and single spikelets, and one which is common in segregates of maize-teosinte hybrids.

The cob fragments from this level, comprising 32 specimens, fall into three more or less distinct groups. The largest number, thirteen, are similar to the intact cobs of Cristalino de Chihuahua mentioned above. The second group, comprising ten fragments, are slender and

eight-rowed. These are pretty obviously cobs of Harinoso de Ocho, or something very much like it. The third group, comprising nine cobs, is intermediate between these. The cobs represent Harinoso de Ocho, only slightly modified by the introgression of other elements. They may be similar to the present-day "Maiz Blando de Sonora," described by Wellhausen *et al* (1952), which, in turn, has some similarity to the Pima-Papago corn of southern Arizona.

There are twelve unclassified fragments from this level.

No cobs which could be clearly assigned to Chapalote are found in this surface level. Apparently, this primitive race was almost completely replaced by Harinoso de Ocho and the modern race evolving from the amalgamation through hybridization of earlier races.

Slab Cave

Trench 2 *(0–12″)*. Five intact cobs, 6.5, 7.5, 7.5, 10, and 9 cm. in length. The first four appear to be cobs of a short-eared form of Chapalote. The last resembles Harinoso de Ocho. Three additional intact cobs, 5.5, 5.5, and 6 cm. in length, are Tripsacoid with indurated glumes and rachises and a slight tendency towards suppression of one member of a pair of spikelets. Two fragments are also Tripsacoid.

The remaining fragments can be separated into three more or less distinct groups. The first, comprising eleven specimens, shows some resemblance to cobs of Chapalote. The second group, nine specimens, are related to Harinoso de Ocho; and the third group, also nine specimens, are similar to the most recent maize from Swallow Cave, which, as already mentioned, is similar to the modern Cristalino de Chihuahua.

The collection from this test trench includes 82 well-preserved kernels, of which fifteen have brown pericarp.

The kernels are thick, wedge-shaped and flinty; and, in these respects, resemble the kernels of Cristalino de Chihuahua. There are no typical kernels of Chapalote, but the influence of this race is apparent in the brown pericarp of a small percentage of the kernels.

Olla Cave

Trench 2, Level 1 (*0–6″*). No intact cobs; ten fragments which may be related to Chapalote; three fragments which show some resemblance to Harinoso de Ocho; one fragment resembling Cristalino de Chihuahua; and three fragments of Tripsacoid cobs. Six kernels (two brown, one red, one yellow, and two white); one of the brown kernels is exactly like those of Chapalote; one of the white kernels is like those of the modern Cristalino de Chihuahua.

Trench 1, Level 1 (*0–6″*). Two intact cobs, both 5 cm. long, both Tripsacoid; and an additional fragment which is Tripsacoid. Of the remaining ten fragments, nine can be assigned to Chapalote and one to Harinoso de Ocho. Five kernels (two brown, one red, one yellow, one white); one brown kernel is typical of Chapalote.

Tau Cave

Trench 1 (*0–18″*). Two intact cobs, 6 and 10 cm. long. The first is a highly Tripsacoid cob with stiff, indurated crateriform glumes and indurated rachis. There is a slight tendency towards the suppression of one spikelet of the pair. The second cob has relatively long, soft glumes and is similar to Chapalote. Three cob fragments resemble Cristalino de Chihuahua, being large in diameter and possessing deep pockets, formed by long, thick, slightly indurated glumes. Seventy-two kernels, of which 63 are brown, one red, and eight white. The brown kernels are

predominantly short and broad, flinty in endosperm texture, and, except for being slightly larger, are similar to those of Chapalote.

Dark Cave

Trench 4, Level 6 (30–36″). About 775 kernels (182 grams, kernels weighing 23.6 grams per hundred). The kernels are almost identical in size, shape and color to the kernels of modern Chapalote (Plate XXXIX, inset, Figs. C and D). A few kernels have red pericarp.

Trench 4, Levels 5 and 6 (24–36″). About 3,000 kernels (709 grams, kernels weighing 23.2 grams per hundred). Like the kernels from Level 6, these are similar to modern Chapalote in size, shape and color. There is very little evidence that this race, at this stage, has been modified by the introgression of other races.

Trench 4, Level 1 (0–6″). One fragment similar to Cristalino de Chihuahua, Five kernels (Plate XLIV); three are small and brown like Chapalote; one is small, white and flinty; one is large and broad, and similar in size and shape to the kernels of modern Harinoso de Ocho. It is the only one from any of the caves referable to this category. It is possible that large, floury kernels would not have been as easily preserved as flinty kernels of other races.

Archaeological Levels and Types of Maize

The relationship between archaeological levels and types of maize is simple, direct, and obvious: 1) All of the maize from the lower levels, 3 to 14 (with the possible exception of two intrusions in Level 3 of Swallow Cave), is related to Chapalote—the only type of maize found at the lower levels; 2) The maize of the upper levels, 1 and 2, comprises four types, Chapalote, Tripsa-

coid, Harinoso de Ocho, and Cristalino de Chihuahua. All four types are present in Swallow, Slab, and Olla Caves. Tau Cave and Dark Cave each lack specimens of one of these types, Harinoso de Ocho and Tripsacoid respectively, but in both cases the total number of specimens is small and the absence of one of the four types has no significance.

The Evolutionary Sequence

The sequence of steps in the evolution of maize in northwestern Mexico is reasonably clear. All of the early maize, whether from Swallow Cave in Chihuahua or Dark Cave in Sonora, is related to the living, but still primitive, race, Chapalote. The earliest maize of this type (from Levels 13 and 14 of Swallow Cave) is smaller and more primitive than modern Chapalote and is a precursor of it. During the period (perhaps a very long one) represented by the difference between Levels 13 and 14, and Levels 1 and 2 in Swallow Cave, there was, except for a slight increase in size, little change in this race. In this respect, the situation is similar to that described by Mangelsdorf *et al* (1956) in the maize of northeastern Mexico, where another ancient indigenous Mexican race, Nal-Tel, remained remarkably constant during a long period of time.

This gradual evolution within a single race was suddenly interrupted when two new entities, an eight-rowed maize originally from South America and Tripsacoid maize, became involved in the evolutionary sequence. With almost explosive rapidity, these three elements now fused to produce an entirely new and highly advanced race of maize similar to the modern race of Cristalino de Chihuahua. This spectacular evolutionary spurt can be accounted for by three genetic phenomena: genetic recombination, heterosis, and the mutagenic effects

of teosinte introgression. Of these three, the last, a phenomenon only recently recognized (Mangelsdorf, 1953), may have been the most important. In any case, the maize of northwestern Mexico, in a short period of time, not more than several centuries at the most, was almost completely transformed.

Approximate Date of Evolutionary Changes

None of the maize specimens from these caves has yet been dated by radiocarbon determinations. Correlations of the cultural manifestations mentioned earlier in this paper suggest that the most recent archaeological remains should be assigned to about 1000 A.D. The sudden changes begin in Level 2 which must represent a date slightly earlier, perhaps about 900 A.D. It is interesting to note that Martin *et al* (1952) in studying the maize from Tularosa Cave, found a gradual decrease in average row number which was attributed, in part, to the introduction of varieties with low kernel-row numbers from outside the area. It was assumed that some of these varieties were Tripsacoid. The change in row number was most sudden between the Georgetown and San Francisco phases (ca. 700 A.D.). Mangelsdorf and Smith (1949) found the earlier maize from Bat Cave to be non-Tripsacoid, while the more recent maize, especially that from Levels V and VI, included a high percentage of Tripsacoid specimens. Cobs from Level VI are dated by radiocarbon determinations at 1752 ± 250 years (Arnold and Libby, 1950) or, at the latest, about 450 A.D. But estimates based on pottery put this level at between 500 and 1000 A.D. More precise dating will undoubtedly become possible as the data from radiocarbon determinations and archaeological manifestations, from various sites, are correlated. In the meantime, it will suffice for our purposes to conclude that a very marked change in

the maize of northwestern Mexico and adjoining areas in New Mexico occurred at about 750±250 A.D.

The Diffusion of Maize from Northwestern Mexico

There can be little doubt that Chapalote, one of the ancient indigenous races of Mexico, was spread rather widely, and was the principal, if not the only race of maize of the early cultures in northwestern Mexico and the southwestern United States. Prehistoric remains of Chapalote, or something closely related to it, have been found by Kelly in the states of Jalisco and Sinaloa in Mexico (Anderson, 1944), by Anderson (1947) in the material from Painted Cave and by Hurst and Anderson (1949) in the maize from Cottonwood Cave in Colorado. Wellhausen *et al* (1952) have pointed out that some of the impressions of maize ears in a prehistoric block of lava from Morelia, Michoacan, Mexico, might well have been made by ears of Chapalote. Although the authors did not recognize it at the time, it now seems apparent that some of the early maize of Bat Cave described by Mangelsdorf and Smith (1949) is related to Chapalote. The cobs from Strata I and II of their Plate XXIII, as well as the kernels (Plate XXIV) are clearly related to this race. The Pre-Pottery maize from Tularosa Cave, illustrated by Cutler (*in* Martin *et al*, 1952), may also well be an early form of Chapalote.

Chapalote is unique among the Mexican races of maize in having brown pericarp color. The center for this character is in the highlands of Peru where brown and reddish-brown pericarp colors are common. Brown pericarp is also common among the prehistoric maize ears of coastal sites in Peru. Whether Chapalote came originally from South America, or whether brown pericarp in Peru derived originally from Mexico, or whether there is, indeed,

any significance in the fact that brown pericarp occurs in both Mexico and Peru, remain for the moment unanswered questions.

There seems little doubt, however, that the eight-rowed maize, Harinoso de Ocho, which features so prominently in the evolution of maize in northwestern Mexico, came originally from South America. And it seems quite probable that this race is related to the prehistoric flour corn of Cañon del Muerto described by Anderson and Blanchard (1942) and to various living races of maize including the Papago flour corn illustrated by Carter and Anderson (1945) and the eight-rowed flour corn of the Indians of the northern Great Plains, illustrated by Will and Hyde (1917).

The race, Cristalino de Chihuahua, like Chapalote and Harinoso de Ocho, seems to have spread throughout the American Southwest. Ears resembling it occur widely among the maize varieties of the Indians. Carter and Anderson (1945) in their study of southwestern maize varieties recognized two of the elements now identified in the archaeological specimens. One of these, a many-rowed maize with tapering ears, was designated as "Mexican"; the other, an eight-rowed corn with large kernels, was called "Eastern." In the light of the archaeological remains described above, it now appears that both of these elements are Mexican, the first, Chapalote; the second, Harinoso de Ocho.

All of the evidence combined points to the conclusion that the highlands of northwestern Mexico served as a corridor for the diffusion of maize from Mexico into the American Southwest.

Summary

1. Collections of prehistoric maize from five caves in Sonora and Chihuahua in northwestern Mexico are described.

2. The earliest prehistoric maize is a precursor of a living primitive race in Mexico, Chapalote.

3. There was little evolution, except for a slight increase in size, in this race during a long period of time.

4. At about 750 ± 250 A.D., the maize of northwestern Mexico began to change with explosive rapidity.

5. This sudden evolutionary spurt is attributed to the introduction into the area of two new entities, an eight-rowed flour corn originally from South America and Tripsacoid maize which had become modified by teosinte introgression.

6. These three entities combined to produce a new race, Cristalino de Chihuahua, which is assumed to be the product of genetic recombination, heterosis, and the mutagenic effects of teosinte introgression.

7. All of the races of maize which occurred prehistorically in northwestern Mexico are found archaeologically or as living maize in the Southwestern United States. It is postulated that the highlands of northwestern Mexico served as a corridor for the northward diffusion of maize.

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EXPLANATION OF THE ILLUSTRATION

PLATE XXXVIII. *Upper.* Swallow Cave, Slab Cave and Tau Cave (second, third and fourth from left, respectively) are located on the face of this cliff in Cave Valley, Chihuahua, Mexico. *Lower.* A view of the interior of Olla Cave, Chihuahua, Mexico, showing a granary in the foreground.